SALMON AND TROUT GO TO SCHOOL

An Instruction Manual for Hatching Salmon and Trout Eggs in Classroom Aquarium-Incubators

SALMON AND TROUT GO TO SCHOOL

An Instruction Manual for Hatching Salmon and Trout Eggs

in Classroom Aquarium-Incubators

Funded by the Steelhead Trout Catch Report-Restoration Card

Written by Diane Higgins

Illustrated by Gary Bloomfield

The mission of the Department of Fish and Game is to manage California's diverse fish, wildlife, and plant resources, and the habitats upon which they depend, for their ecological values and for their use and enjoyment by the public.

American Fisheries Society
Humboldt Chapter

The American Fisheries Society, founded in 1870, is the oldest and largest professional society representing fisheries scientists. AFS promotes scientific research and enlightened management of aquatic resources for optimum use and enjoyment by the public. It likewise encourages a comprehensive education for fisheries scientists and continuing on-the-job training.

First Edition, January 1996

revised in September 2003 by Department of Fish and Game,
San Joaquin Valley and Southern Sierra Region

Table of Contents

Introduction

When salmon and trout go to school, students have a unique opportunity to witness their birth and care for them during their early life stages. In the process, your students will learn important concepts, while developing caring attitudes about the fish and their habitats.

The salmon and trout incubation unit encompasses science, math, art, social studies and language arts. It is a sound stepping stone to many topics, and can easily be integrated into existing curriculums at any grade level.

The goal of this program is to help young people become good stewards of all our aquatic resources, including salmon and trout. Salmon and trout are especially valued wildlife in California, but sadly, most wild populations are dwindling. Students raise these fish to learn about their habitat requirements and how to keep habitats healthy, so the wild fish may thrive once again.

How to Get Started

The California Department of Fish and Game coordinates teacher workshops for this program. At the workshop, you will learn some basics about the fish, how to set up the equipment, and some curriculum ideas. The workshop facilitator will explain the procedures for getting eggs and may give you phone numbers of volunteers willing to help you with the project. See page 7 for information regarding the Salmonids in the Classroom program coordinator in your region.

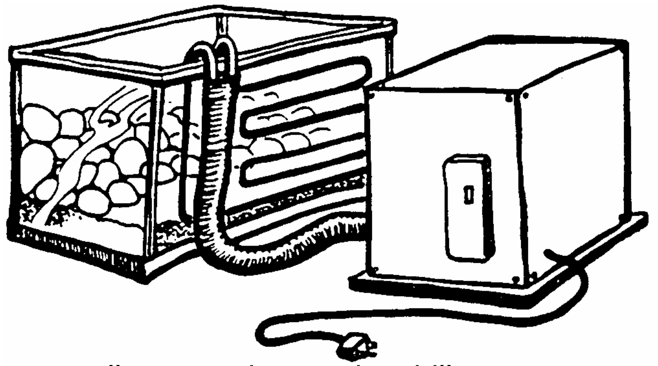
The California Department of Fish and Game (CDFG) requires an approved authorization form before the fish eggs will be supplied to you. The authorization gives you special permission to keep eggs in your classroom and to release the fry at a designated site in the wild. That site may not be in your own watershed, so be aware that you may need to travel some distance to release your fry.

Read through this manual. It explains the materials you need, and how to set up and maintain the aquarium incubator and successfully raise a healthy batch of salmon or trout. This manual contains activities related to the rearing project. You will probably want to supplement these activities with other lessons to suit the needs and interests of your students. The bibliography lists curriculum resources that will help you build a unit of study about salmon and trout.

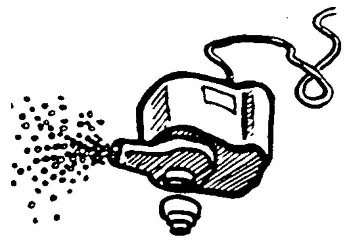
Equipment you will need

- Aquarium, 5-20 gallons depending on the chilling method you choose.
- Chiller or refrigerator (see appendix for sources)
- Power head pump appropriate for your aquarium size
- Under gravel filter
- Gravel; pea size; enough to cover the bottom of the aquarium to the depth of one inch.
- Rocks; smooth, round river rocks with a diameter of 1 - 2.5 inches (enough to cover the front half of the bottom of your aquarium).
- Aquarium thermometer
- Aquarium net
- Baster; plastic bulb style turkey baster
- Plastic bucket; not metal, not previously used for chemicals or cleaning products.
- Siphon to remove dirty water and waste at the bottom of the tank.
- Non-chlorinated water
    - Do not use distilled water or bottled drinking water that is filtered enough to be almost distilled
    - River water that has boiled at a rolling boil for at least 10 minutes
    - Clean, untreated well water
    - Tap water that has set out in an open container for at least overnight or has been treated for chlorine with a solution available at pet stores.
- A cover for the refrigerator window or aquarium if you have a chiller unit to keep light off the eggs.
- Fish food. The hatchery may provide fish food which should be kept in the freezer if possible or the refrigerator. If it is not supplied, ask your program coordinator for suggestions.
- Battery-operated aquarium air pump and air stone is optional. This can be used to aerate the tap water and expedite the evaporation of the chlorine before putting the water into your aquarium. It is also helpful to the fry on the way to the river if you have to transport them for more than 30 minutes.
- *Optional,* iodine-based disinfectant, beta dine, available at drugstores. This should be used ***sparingly*** to disinfect equipment. Equipment should then be rinsed **extremely** well. Very small amounts of residue may not kill the eggs but can kill the fish when they hatch.
- Ammonia Test Kit (can be found at local pet stores)
- Ammonia/Nitrate Buffer

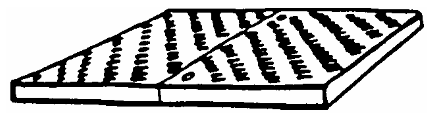
Equipment at a Glance



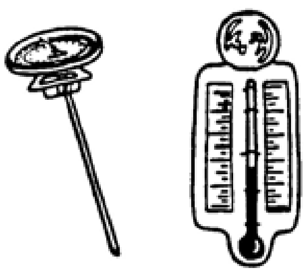
20 gallon aquarium and a chiller (shown) or a chilled aquarium in a converted refrigerator.
(see Appendix A.)



Power head pump, **air tube** and uplift tube



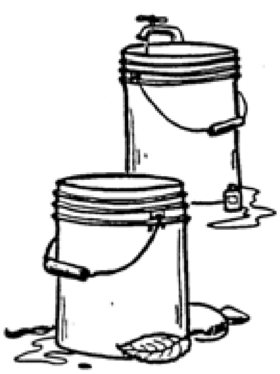
Under Gravel Filter



Thermometer

Food

River Rock or Large Gravel

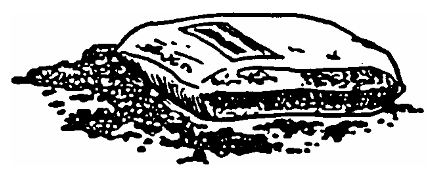


Clean non-chlorinated water (see Page 2)

Or

Water from stream or local river, <u>*boiled for ten minutes.*</u>

Pea Gravel



<u>PLUS</u>
Baster
Buckets
Dip Net
Disinfectant
Siphon

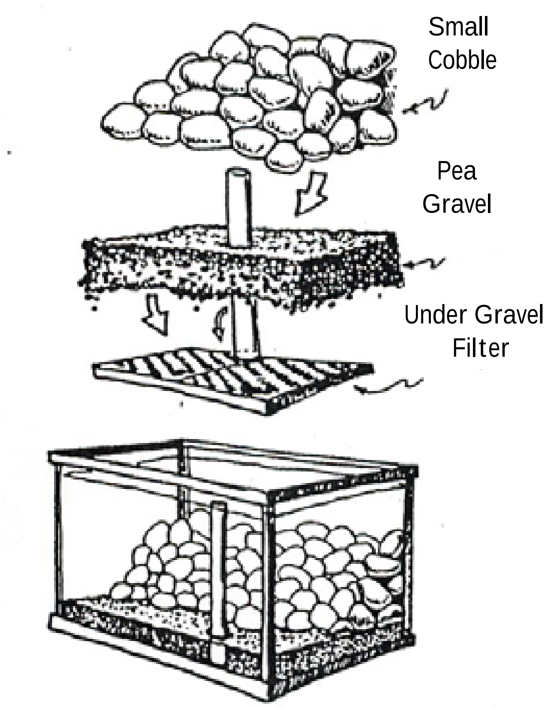
Set Up

The aquarium incubator should be set up at least two weeks before the eggs arrive in your classroom. This will allow you to monitor and stabilize the water temperature and check for problems with the equipment. Two weeks early may sound like a long time but not all problems are immediately evident. If a problem arises you'll be glad you have the extra time to fix it.

1. Gather River Cobble

2. Disinfect pea gravel and river cobble. Soak in disinfectant solution or boil 10 minutes.

3. Disinfect all equipment that has been used before with a Wescodyne solution or soak all parts in a one part bleach to ten parts water for 24 hours. This includes: aquarium, under gravel filter, air pump, thermometer, baster, net, siphon and buckets. Rinse thoroughly to remove all residue of disinfectant. Let set for 24 hours after bleach solution is used.



View from the back

4. Assemble Under Gravel Filter & Uplift Tube
   A) Decide on position for the air pump and punch the hole out of the under gravel filter.
   B) Twist hard plastic uplift tube into the filter base. Extend tube as needed. If necessary, add additional tubing with plastic extender rings.
   C) Place filter inside aquarium
   D) Fit the uplift tube to the air pump nozzle.

Place Pea Gravel and River Gravel in Aquarium
   A) Gently pour enough pea gravel to completely cover the filter. (About 1 to 2 inches deep). The small gap between the filter and aquarium wall must be filled with gravel. Alevin can burrow, and if they get under the filter, they will be sucked into the air pump.
   B) Carefully place river cobble in the front half of the aquarium. Leave the back half covered only with pea gravel. This will make cleaning easier and observation of the eggs and alevins visible. There will be small spaces between the rocks. This is where you will place the eggs.

6. Fill the tank with water to about 2 inches from the top.

7. Place the power head pump in the filter uplift tube. Attach it to the side of your aquarium.

8. Put aquarium thermometer in the water. Make sure you can see it easily.

FOR CHILLERS: Follow manufacturer's instructions. Set temperatures to 50^{o}.
FOR MODIFIED REFRIGERATORS: See directions for converting a refrigerator

Caring For Your Eggs and Fish

All salmonids need clean, cold water with plenty of oxygen with a pH balance of 5.8 to 9.6, ideally 7-8, and nitrate levels no higher than I ppm (parts per million). If you provide these conditions and keep the aquarium clean, your fish rearing experience should be successful.

Set up your aquarium incubator at least two weeks before the eggs are delivered to make sure the system is working properly and the temperature is steady.

Placing Eggs. - Eggs are usually transported in a cheesecloth sack or ziplock baggie packed in ice. Put them into your aquarium as soon as they arrive in the classroom, but first, turn off the Powerhead. Make sure your hands are clean and free of soap or lotion. Carefully drop the eggs, several at a time, along the front of the aquarium. They will settle into the spaces between the rocks along the front of your aquarium. Students will be able to see the eggs develop and hatch.

Providing Darkness - Eggs and alevin are harmed by light. They can take brief periods (about 30 minutes) of exposure to natural light without damage. To provide darkness, cover the front window of the refrigerator with black felt or construction paper, or find a large box that will completely cover your chiller and cut as needed to fit around the chilling unit hose and air hose. You can also tape sheets of paper to the aquarium sides. Leave the bottom and sides untapped in front, so it can be lifted for viewing, or cut out a viewing window. Paper covering the top of the aquarium may be affected by moisture, so beware of inks and paper die that can drip into the water. Aquariums inside refrigerators will be sufficiently dark unless they face a bright window or light. You can make a curtain or screen for the window.

Removing Dead Eggs - Some eggs may die, even in good conditions. Live eggs are pink to orange. Check the tank carefully every day and use the baster to remove any white, milky eggs.

Hatching - The embryo produces an enzyme that dissolves the egg's shell. You may notice a little white foam on the surface at hatching time. Don't be concerned, it will not hurt the fish. If egg shells remain just after hatching, eggshells should be removed by changing half the water or using the baster to remove them to prevent fungus growth.

Alevin Stage - Little care is required at this stage. Continue to check for dead alevin and remove them immediately. The tiny alevin will remain in the gravel and will avoid light. Keep the incubator in darkness.

Feeding - After they become free swimmers and swim out of the gravel, the fish need food. When you put food in the water, watch as it falls. Try to feed just enough so that no food reaches the bottom of the aquarium. Decaying food will contaminate the water and could kill your fish. Feed several times each day, but no more than once per hour. They can survive a two day weekend with no food, but feeding arrangements should be made for longer breaks.

Keeping Your Tank Clean

From the moment your eggs arrive, it is important to stay on top of things. After trying different approaches to tank cleaning, testing the water for toxic ammonia/nitrate levels has been the best solution.

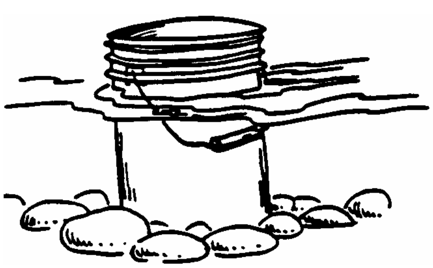
An ammonia test kit can be purchased at most local pet stores. This kit allows you to check the ammonia/nitrate levels to maintain a healthy tank.

After you have set up your tank, read the directions on the test kit and begin testing and graphing your tanks water. This has a dual benefit: 1) It allows you and your student to practice graphing and reading scientific results and 2) It establishes a control so you can easily diagnose deteriorating water conditions. Once your eggs are delivered, testing the water daily is extremely important. Should you have decaying eggs hidden somewhere in the rocks, the nitrate level should start to shift. Make sure your tank remains free of dead eggs, alevin or fish.

Once the alevin become free swimming fry, daily testing and cleaning are a must. It is best to remove the river rock or large gravel at this time as you will be cleaning the pea gravel daily with your siphon. Should your ammonia/nitrate levels begin to rise, siphon out (from the gravel) one-fourth to one-third of your water, until the levels becomes safe.

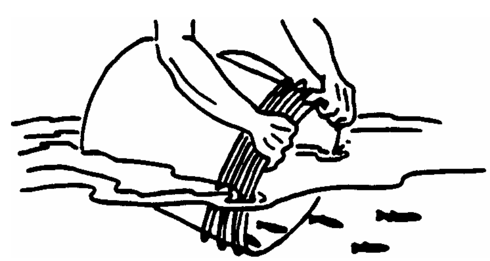
Cleaning the Water - After hatching, the fish produce more waste, so the water must be siphoned from the pea gravel regularly (*<u>always siphon into a bucket to catch runaway fry</u>*). It is best not to remove more than one-fourth to one-third of your aquarium water daily. The clean water must be the same temperature as the aquarium water. If you use a refrigerator for your cooling system, rotate your clean water on another shelf daily so that you always have aquarium ready water. If you use a chilling unit, refrigerate the water and check the temperature with a thermometer before adding to your aquarium. Use your fish net to replace any fry that accidentally get siphoned from the aquarium. Work quickly as this is stressful to the fish.

Cleaning the Gravel. - Use the baster to lightly blow air into the gravel, which will dislodge particles of debris. You may also use an aquarium siphon, but be sure to dump the dirty water into a bucket, not directly down the drain, so you can rescue fry. Clean the gravel daily after hatching. Do this by placing the siphon down into the gravel and agitating the gravel.



Releasing the Fish -This is a very stressful day for your fish. They should be moved as quickly as possible. Drain half the water from the tank and scoop the fish into a disinfected 5 gallon plastic bucket or cooler. Allow about 45-60 minutes to transfer all the fish. If you must travel some distance, or if it is very warm, float a plastic baggie with ice in it, and you can aerate your water by simply scooping up cups of water and pouring them back in from the height of about six inches. You can also find portable battery operated air pump and air stone at many local pet stores or tackle shops. Keep the water cool and oxygenated. Be sure not forget to take a thermometer.

At the release site, you must gradually bring the water in the bucket to the same temperature as the stream. This may take a little time, so have something planned for your students to do. See Farewell Finny Friends, page 32, for information about releasing fish.



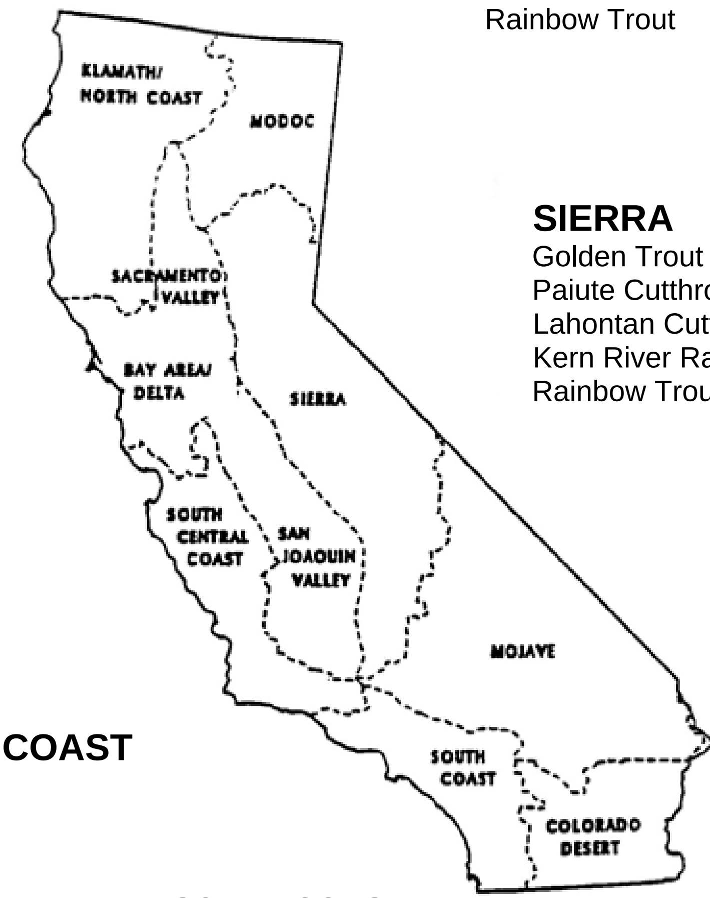
Contacting the California Department of Fish and Game

If the County in which the project will take place is. . .	Contact the Salmonids in the Classroom Coordinator at:
Del Norte, Siskiyou, Modoc, Humboldt, Trinity, Shasta, Lassen, or Tehama	Northern California and North Coast Region, 601 Locust Street, Redding, CA 96001; (530)225-2300
Glenn, Butte, Plumas, Colusa, Sutter, Yuba, Nevada, Sierra, Yolo, Placer, Sacramento, eastern Solano, Amador, El Dorado, Alpine, Calaveras or, San Joaquin	Sacramento Valley and Central Sierra Region, 1701 Nimbus Road, Rancho Cordova, CA 95670; (916) 358-2900
Mendocino, Sonoma, Lake, Napa, Marin, western Solano, Contra Costa, Alameda, San Francisco, San Mateo, Santa Clara, Santa Cruz, San Benito, Monterey, or San Luis Obispo	Central Coast Region, 7329 Silverado Trail, Yountville, CA 94599; (707) 944-5500
Stanislaus, Tuolumne, Merced, Mariposa, Madera, Fresno, Kings, Tulare, or Kern	San Joaquin Valley and Southern Sierra Region, 1234 E. Shaw Avenue, Fresno, CA 93710; (559) 243-4005
Santa Barbara, Ventura, Los Angeles, Orange, or San Diego	South Coast Region, 330 Golden Shore, Suite 50, Long Beach, CA 92123;(562)590-5870
Mono, Inyo, San Bernardino, Riverside, or Imperial	Eastern Sierra and Inland Deserts Region, 4775 Bird Farm Road, Chino Hills, CA 91709;(909)597-9823

NATIVE SALMONIDS OF CALIFORNIA

KLAMATH/NORTH COAST
Fall Chinook Salmon
Spring Chinook Salmon
Coho Salmon
Coastal Cutthroat Trout
Winter Steelhead Trout
Summer Steelhead Trout

MODOC
McCloud Red Band Trout
Eagle Lake Trout
Goose Lake Red Band Trout
Rainbow Trout



SIERRA
Golden Trout
Paiute Cutthroat Trout
Lahontan Cutthroat Trout
Kern River Rainbow Trout
Rainbow Trout

SACRAMENTO/ SANJOAQUIN VALLEY
Fall Chinook
Winter Chinook
Spring Chinook
Coho Salmon
Winter Steelhead Trout
Rainbow Trout
Note: 3 bioregions have been combined on this map.

SOUTH CENTRAL COAST
Coho Salmon
Winter Steelhead Trout
Rainbow Trout

SOUTH COAST
Steelhead Trout
Rainbow Trout

- Native fish have evolved in their current range.
- Wild fish may be native or non-native in origin. They live and spawn in the wild.
- Hatchery fish are spawned and reared in hatcheries. They may be native or from another region.

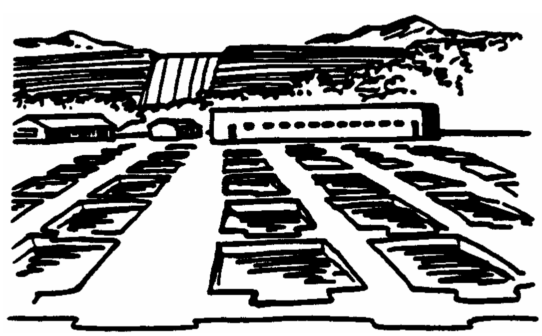
Why Hatcheries?

Anadromous salmonids (salmon and steelhead trout) once ranged into most of California's river systems. Historically, their habitats included many spawning grounds which are now blocked by dams. Almost all of California's major salmon and steelhead producing rivers have been dammed over the last fifty years to provide water and power. In many cases, hatcheries have been built near these dams to mitigate for lost natural fish production. These hatcheries produce millions of salmon, which supplement natural production and enhance commercial and sport fishing along most of California's coast. Trout stocking programs provide sport fishing opportunities in many reservoirs, lakes, and streams throughout California.

The California Department of Fish and Game, aware of the need to protect wild fish populations, has developed guidelines to minimize the impact of hatchery planting on wild fish. Concerns include possible genetic changes in wild fish populations when they interbreed with hatchery fish, and potential competition between hatchery and wild fish. Hatcheries are also managed to reduce the potential for spreading diseases between hatchery and wild populations.

The Department of Fish and Game is using artificial rearing to help save one of the state's important symbols: the Golden Trout. They trap and spawn wild Golden Trout and raise them in a hatchery. The young hatchery-reared fish, of wild origin, are then released into mountain lakes, and into much of their former range.

Many native runs of salmon and steelhead are either threatened, endangered or extinct. Each run (or stock) offish is thought to have a unique gene pool that has evolved over many generations. The genes are responsible for physical and behavioral traits that allow the fish to survive the particular conditions of their river system, such as seasonal flow patterns and water temperatures, and distance to the ocean. Scientists are concerned about losing these gene pools. Hatcheries that propagate native runs offish can play an important role in saving salmon and steelhead. As habitats are restored, they will once again support fish. If the fish must be reintroduced, those reared from a native stock will be most likely to survive and thrive.



Fish Journals

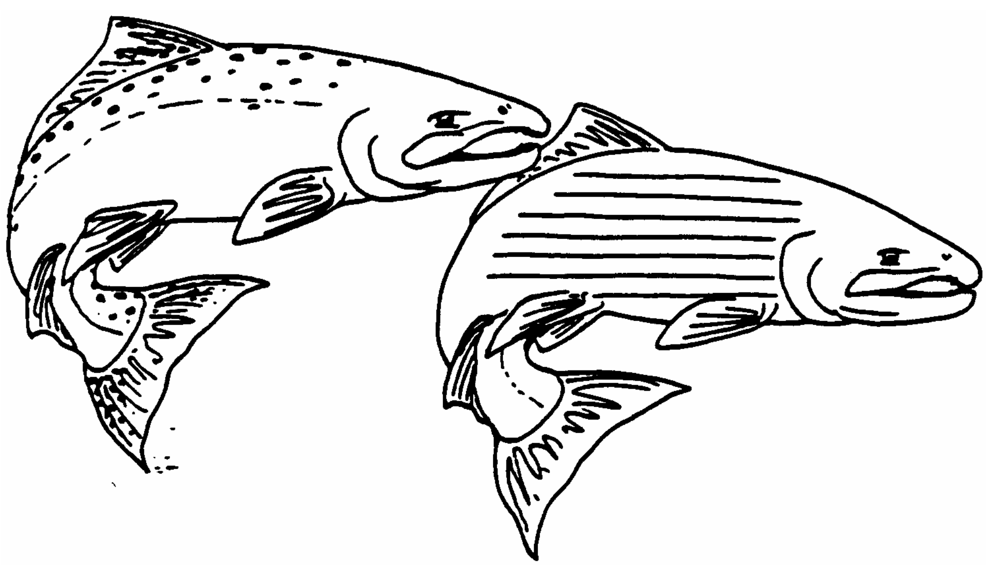
Students keep a journal detailing the experience of raising and releasing salmon or trout.

Materials:
- writing paper
- construction paper for cover
- pencils and crayons

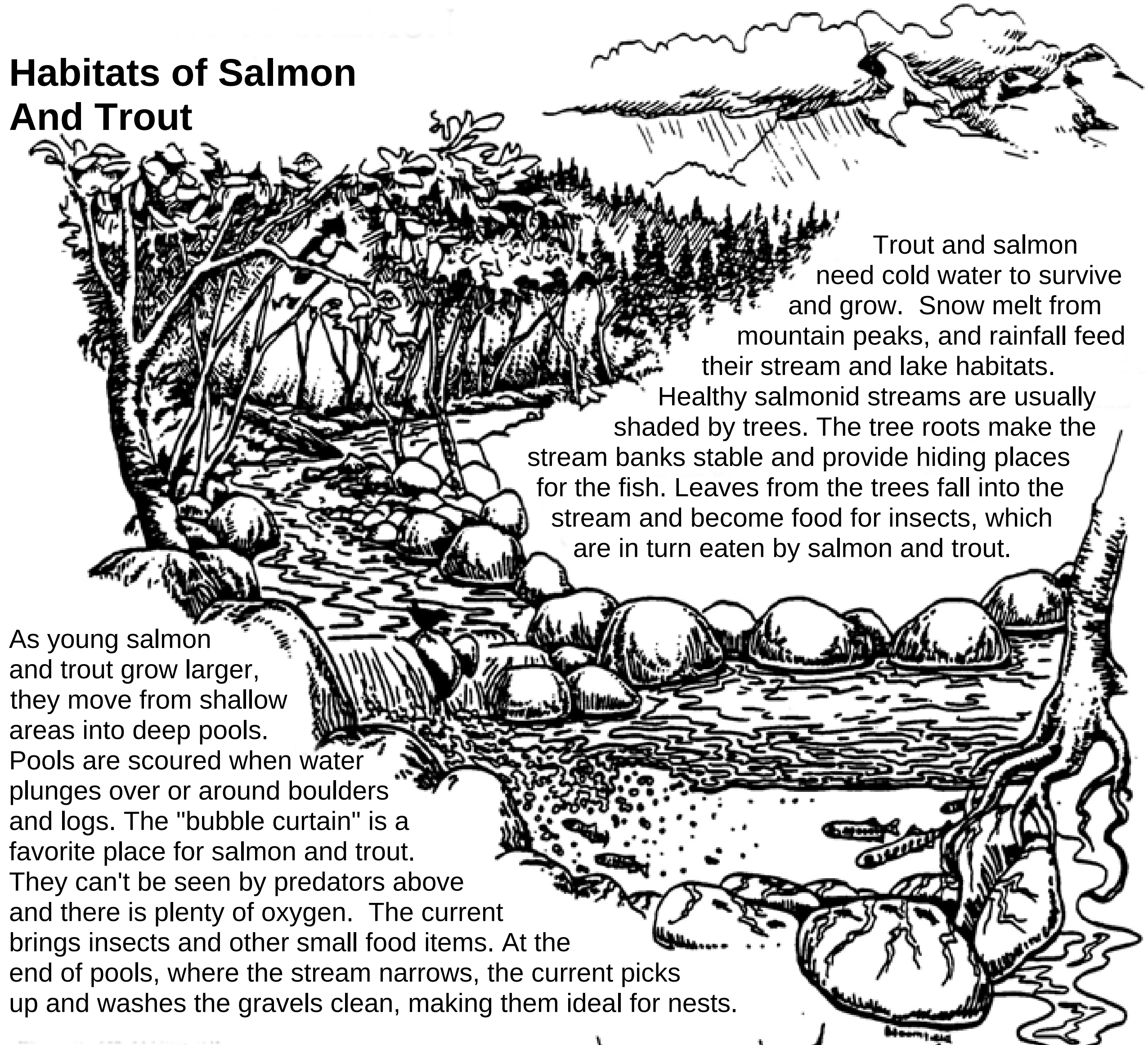
Rearing fish in your classroom will generate many opportunities for observing, recording, measuring, forming and answering questions, writing, drawing and calculating. Journals are a natural place to keep all this material. Students should be encouraged to write daily entries about notable events - from setting up the aquarium to the day fish are released. Also include the thermal unit chart and predictions about hatching date, records of actual hatching and swim-up dates, descriptions of changes as fish grow, drawings of fish at various stages, life cycle charts and drawings of habitats, etc.

Students could also include summaries of guest speakers, slide shows and videos seen as part of this unit. Poetry and other creative writing assignments, along with art work will provide an artistic aspect to an otherwise scientific journal.

The journals may be made with regular sheets writing of paper or you can make custom designs, like the one below. The fish shaped journal works especially well for creative writing projects. Charts, graphs and student worksheets are best kept in student made folders.

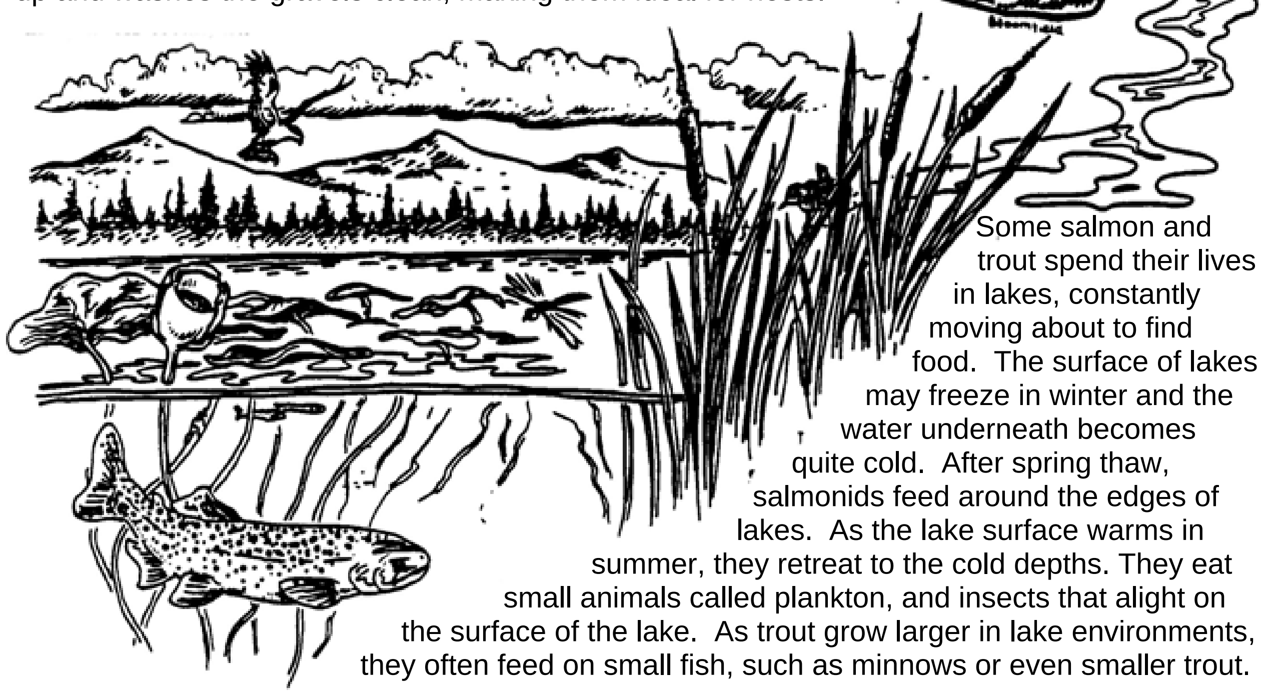


Habitats of Salmon And Trout



Trout and salmon need cold water to survive and grow. Snow melt from mountain peaks, and rainfall feed their stream and lake habitats. Healthy salmonid streams are usually shaded by trees. The tree roots make the stream banks stable and provide hiding places for the fish. Leaves from the trees fall into the stream and become food for insects, which are in turn eaten by salmon and trout.

As young salmon and trout grow larger, they move from shallow areas into deep pools. Pools are scoured when water plunges over or around boulders and logs. The "bubble curtain" is a favorite place for salmon and trout. They can't be seen by predators above and there is plenty of oxygen. The current brings insects and other small food items. At the end of pools, where the stream narrows, the current picks up and washes the gravels clean, making them ideal for nests.

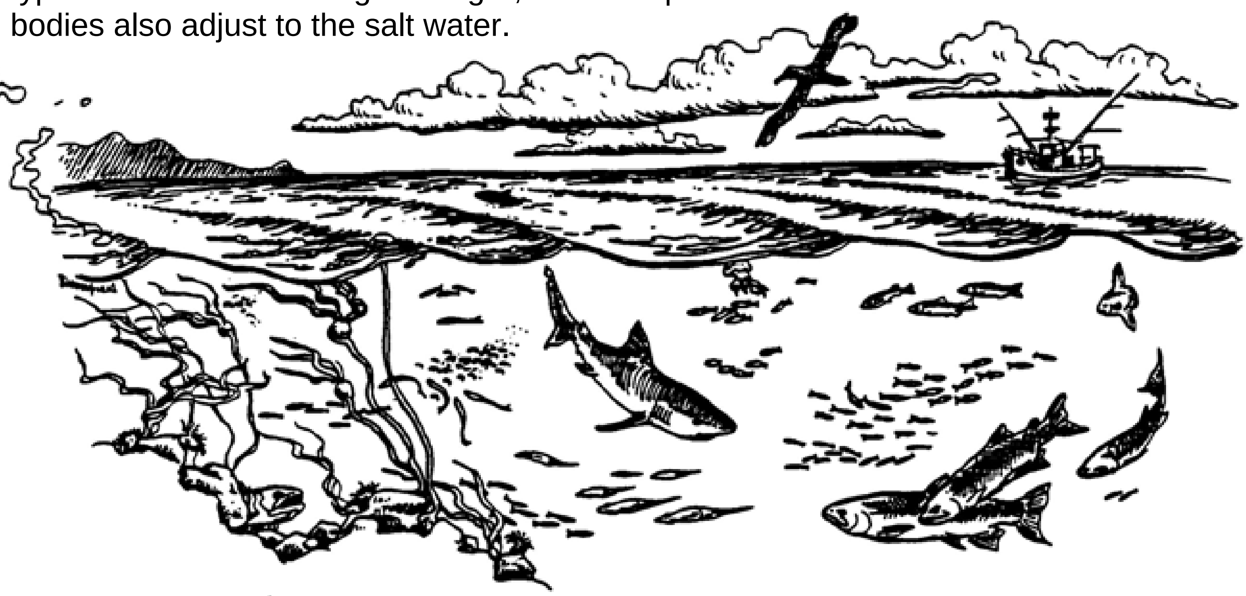


Some salmon and trout spend their lives in lakes, constantly moving about to find food. The surface of lakes may freeze in winter and the water underneath becomes quite cold. After spring thaw, salmonids feed around the edges of lakes. As the lake surface warms in summer, they retreat to the cold depths. They eat small animals called plankton, and insects that alight on the surface of the lake. As trout grow larger in lake environments, they often feed on small fish, such as minnows or even smaller trout.

SEAGOING SALMON AND STEELHEAD

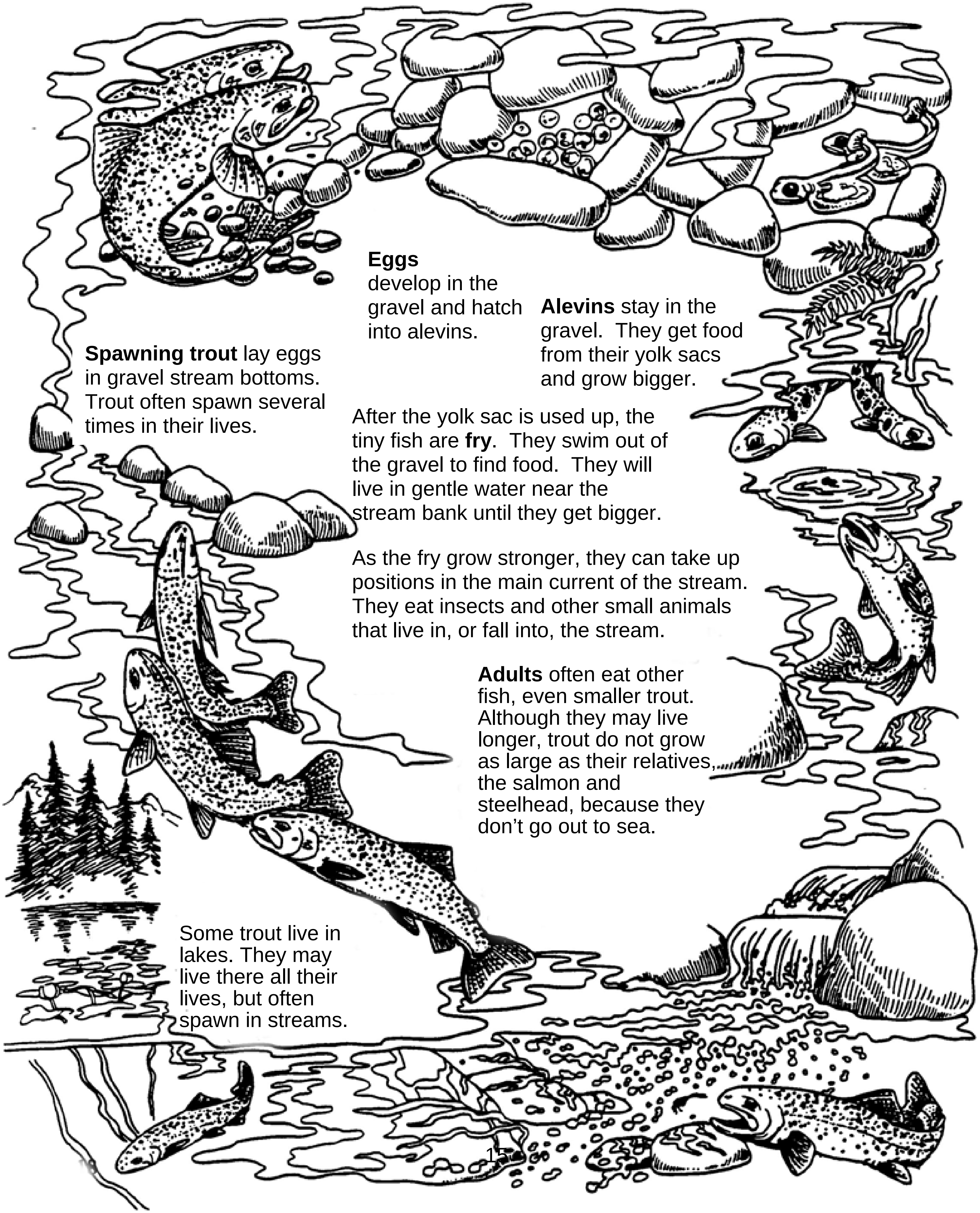
Anadromous salmonids spend part of their lives in salt water. Chinook salmon, Coho salmon. steelhead trout and coastal cutthroat trout are all Anadromous. These fish leave their streams and migrate out to the ocean, where they grow much larger than salmonids that stay in the stream all the time. Chinook usually move into the estuary when they are several months old. The other anadromous fish all spend at least one year in the stream before migrating to sea.

At the river's mouth, fresh water flows into the sea. The sea also surges into the river, and salt water mixes with fresh water. This area of brackish water is the estuary. Migrating fish stay in the estuary for a while before entering the ocean. They find new types of food to eat and grow larger, which helps them survive in the ocean. Their bodies also adjust to the salt water.



The ocean is a vast resource for the fish. They find much to eat, and they grow very large. Cutthroat trout usually keep close to the river's mouth, and stay for only a few months, so they remain fairly small. But salmon and steelhead stay in the ocean for several years and grow very large. They may swim many miles up and down the coast line. California's north coast is one of the places richest in food in the Pacific Ocean.

TROUT LIFE CYCLE



Spawning trout lay eggs in gravel stream bottoms. Trout often spawn several times in their lives.

Eggs
develop in the gravel and hatch into alevins.

Alevins stay in the gravel. They get food from their yolk sacs and grow bigger.

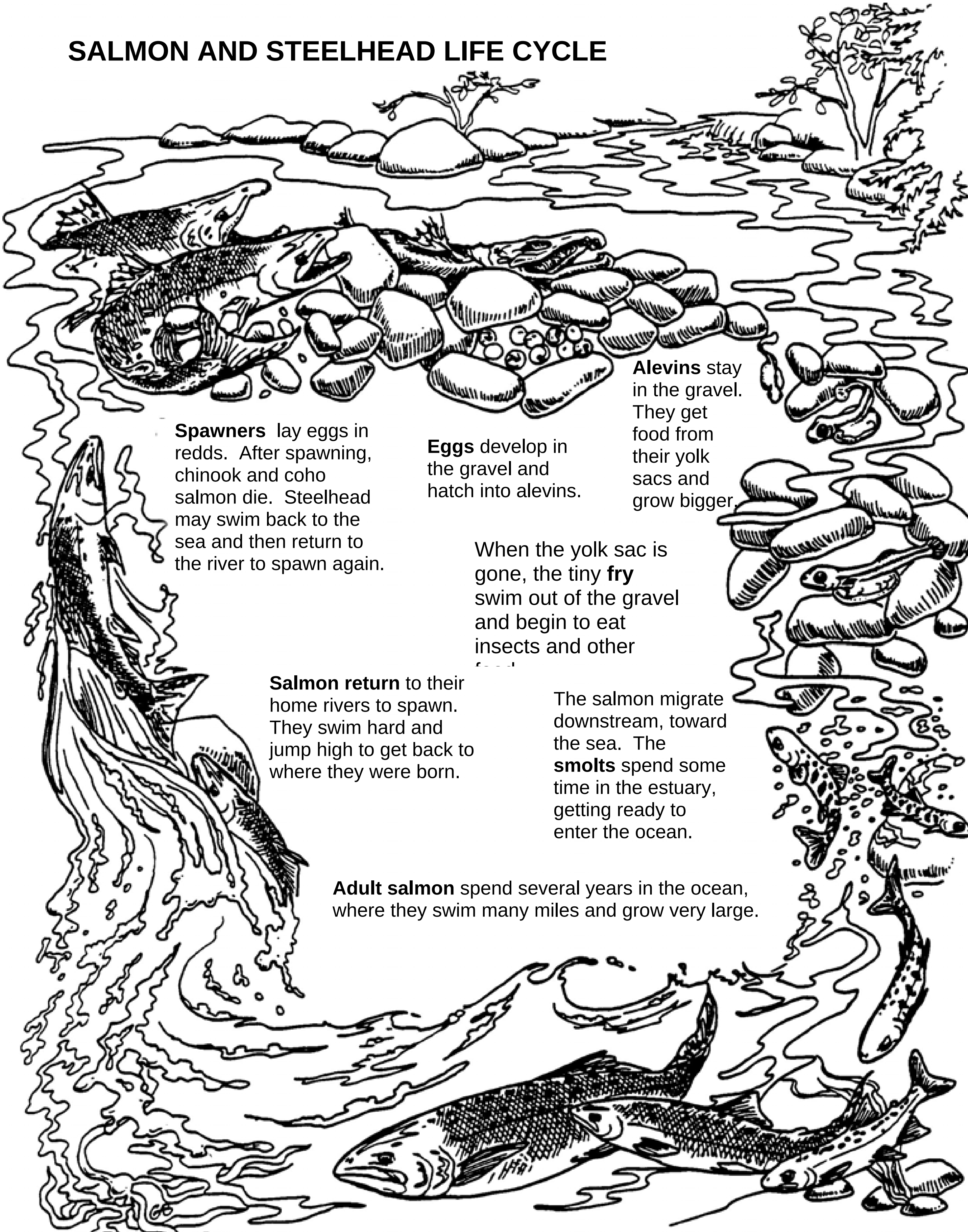
After the yolk sac is used up, the tiny fish are **fry**. They swim out of the gravel to find food. They will live in gentle water near the stream bank until they get bigger.

As the fry grow stronger, they can take up positions in the main current of the stream. They eat insects and other small animals that live in, or fall into, the stream.

Adults often eat other fish, even smaller trout. Although they may live longer, trout do not grow as large as their relatives, the salmon and steelhead, because they don't go out to sea.

Some trout live in lakes. They may live there all their lives, but often spawn in streams.

SALMON AND STEELHEAD LIFE CYCLE



Making A Home

Students design and help construct an artificial environment that will support salmon or trout.

Materials

- Video or slide show
- Life Cycle Charts for salmon & trout, pages 18-19
- *Salmon and Trout Environmental Needs,* page 23
- *How Your Aquarium imitates Nature,* page 22.
- Paper and pencils
- Aquarium Incubator Equipment

This first activity will set the tone and learning objectives for the unit. The focus of this project should be salmon and trout life cycles, habitat needs, and how humans can keep aquatic habitats healthy. The aquarium is used to demonstrate important elements of stream environments.

Some students may have limited knowledge of what rivers and streams are like. To help them develop some concept of aquatic environments, show a video or slide show. The slide show, *California 's Salmon and Trout,* presents a good overview of fish habitat requirements at each life stage. You may also choose a video from the bibliography in this manual.

Another way to introduce children to river habitats is to visit one. Some teachers like to take their class to the hatchery. If you do, try also to visit a site on the river where you can see how fish live and spawn in the wild.

After viewing the slide show or video, help students summarize what they learned. Use the life cycle charts and discuss the different stages, and where the fish live during each stage. Then help students complete the *Salmon and Trout Environmental Needs* worksheet. All this information is presented in the slide show. Students may need some assistance in gathering information from the videos, since they move quickly and do not lend themselves to questions during viewing.

You will have the fish during the egg, alevin and early fry stages. Ask students to design an environment that will keep the fish alive and healthy while they are in your classroom. They must take into consideration all the needs of salmon and trout. Give students time to draw and label their artificial environments and to describe how each component works and how it imitates nature.

Here is what the fish need, how your aquarium will provide those needs, and how nature does it.

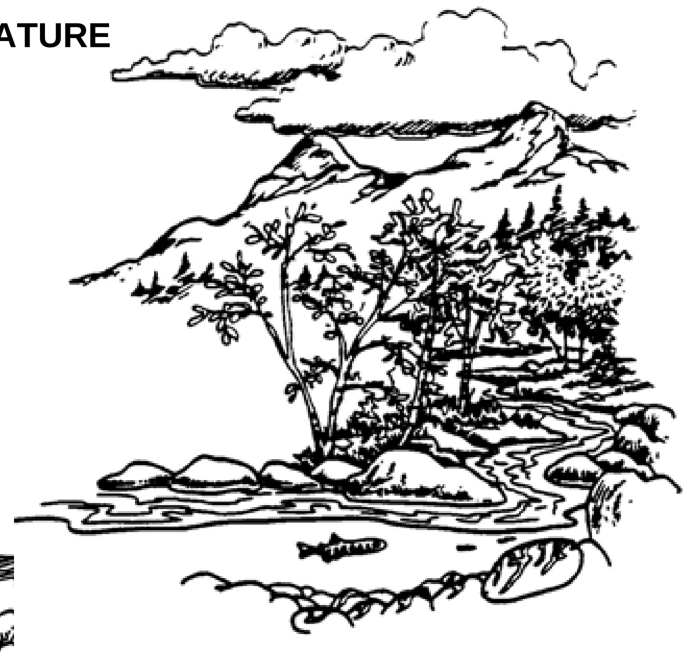
FISH NEED	HOW AQUARIUM PROVIDES	IN NATURE
Cold Water 42° – 55°	Refrigerator or chiller	Cold run off from mountains and springs – Shade
Clean Water	Unpolluted water sources, filter system and routine cleaning	Bacteria break down decaying matter and scavengers eat it. Plants take up nitrates. (Pollutants from people can hurt rivers.)
Oxygen 7-12 ppm	Air pump adds oxygen to water. Cold water holds more oxygen	Water is cold and tumbles down hill, picking up oxygen from the air. Plants add oxygen.
Protection from direct light as eggs and alevin	Covered with box or paper or kept in dark refrigerator	Eggs are buried up to 2 feet deep in gravel.
Protection from predators	Not an issue – no predators	Buried eggs are safe from birds and amphibians, but some insects prey on them. Fry have parr marks and hide under and in boulders, logs, rot wads and undercut banks.
pH range of 6.5 – 7.5	Frequent cleanings and exchange with air help maintain balance	Rock types, amount of plants and decaying matter in water, and animal wastes all affect pH.
Food	Fish chow	Aquatic insects living in gravel, other insects that fall into water, any small animals fish can find, including other fish.
Gravel	You will place in aquarium	Rocks erode from watershed, get washed into streams and are tumbled smooth.

Student designs may not include the same materials you will actually use. This is all right, as long as they think of a way to supply each of the habitat requirements.

Give students the page titled *How Your Aquarium Imitates Nature.* Discuss the components of the aquarium and how they will provide an environment where fish can survive. Talk about how nature provides these conditions. What are the limitations of your artificial environment?

Students should help put the aquarium together.

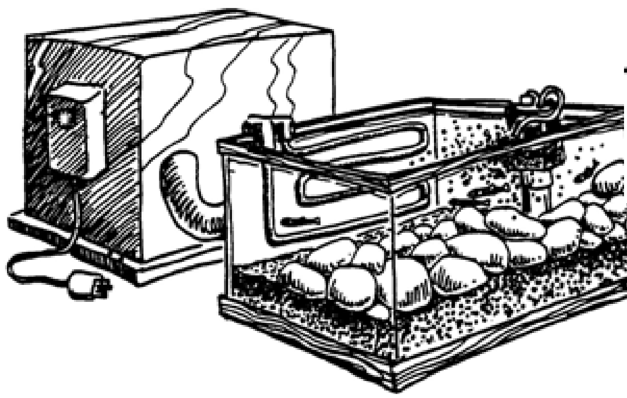
HOW YOUR AQUARIUM IMITATES NATURE



A CHILLER OR REFRIDGERATOR KEEPS WATER COLD.

Real streams stay cold because they-

- receive water from melting snow .
- are fed by underground streams
- are shaded by streamside trees and shrubs

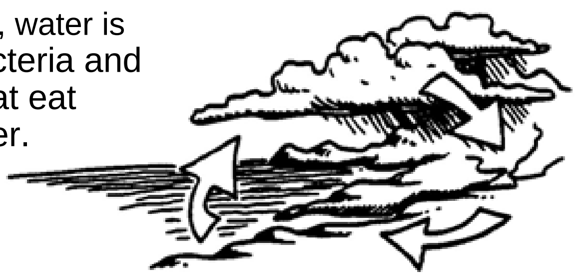


THE AIR PUMP adds oxygen.

In nature, stream water has lots of oxygen because-

- It tumbles over boulders and waterfalls, mixing with the air.
- It is cold -cold water - holds more oxygen.

THE FILTER HELPS CLEAN THE WATER In nature, water is cleaned by bacteria and scavangers that eat decaying matter.



The **water cycle** provides **fresh water.** Clean, fresh water is a precious resource.

GRAVEL protects salmon and trout eggs and alevin from predators in the wild. Rocks wash into streams from the watershed and are tumbled smooth. Aquatic insects also live in the gravel.

Salmon and Trout Environmental Needs

Spawning fish need ______________________________

____

____

Returning adults need

____

____

Eggs need ______________________________

____

____

Adults need

____

____

____

Fry need ______________________________

____

____

Smolts need ______________________________

____

When Will They Hatch?

Students predict when their fish will hatch and when the alevin will swim out of the gravel. They monitor temperature daily, calculate actual Thermal Units (TU's) and compare with predictions.

Materials:

- Thermometer
- Calendar
- Student Worksheets
- Transparency of TU Chart
- Calculators

Salmon and trout eggs develop at a rate that is partially determined by water temperature. Water at temperatures preferred by salmon may feel pretty cold to us, but it still contributes thermal energy to the developing embryo. This energy is measured in thermal units. When the embryo has accumulated enough thermal units, it hatches. The number of thermal units it needs depends on average temperature. Eggs in very cold water will take considerably longer to develop because there is less heat energy available and because they must accumulate more heat energy (thermal units) overall to hatch. Note that the temperature range is limited. Optimal temperatures are about 40-55 degrees F. Eggs will survive temperatures close to freezing, but develop very slowly. If the water is too warm, the eggs die.

1 TU = 1^{o} F **above freezing (32^{o}) for 24 hours**

Example at 52^{o}: 52-32 = 20 20 TU's will accumulate each day (24 hours)
Over a 5 day period, 5 x 20 = 100 TU's will accumulate.

For Steelhead and Rainbow Trout

Water Temperature ^{o}F	Approximate Days To Hatch	Thermal Units Accumulated
40^{o}	80	640
45^{o}	48	624
50^{o}	31	558
55^{o}	24	552
60^{o}	19	532

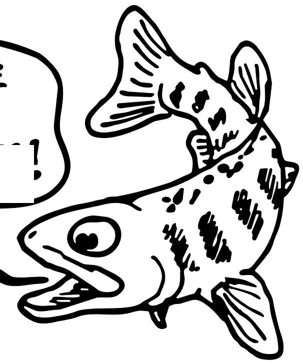
At 45^{o} – 50^{o} F	Chinook Salmon	Coho Salmon
TU's To Hatch	900 – 950	750 – 850
TU's To Emerge	1500 – 1550	1250 - 1300

When will they hatch?

_____________ need ___________ T.U. to hatch.

Hatchery Data:

AVERAGE TEMPERATURE MINUS 32 DEGREES = !



Date eggs were fertilized: __________

Date eggs arrived in your room: __________

TOTAL DAYS spent at hatchery [ ]

Average hatchery water temperature [ ]

[ ] T.U./day × [ ] days = [ ] T.U.

In The Classroom:

Total T.U. required for hatching: __________

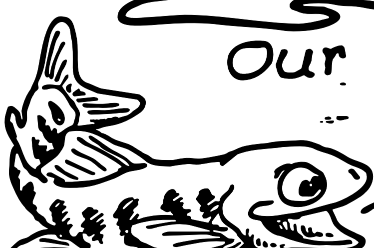
at hatchery: __________

s still needed: [ ]

→ Average daily temperature has been: [ ]

This means that [ ] D.T.U. will accumulate each day.

Our fish will hatch in [ ] days!



The date will be: [ ] !

Procedure:

You will need to know when the eggs were spawned and what the average water temperature was at the hatchery. Be sure to ask the hatchery manager, or the program coordinator for this information along with how many TU's are usually required for eggs to hatch and for swim up. The numbers in the charts above are close approximations; however, there can be slight differences among stocks of fish. Also the total number of TU's required depends on temperature. Where extremely cold conditions exist, more TU's are required than at warmer temperatures.

If your predictions indicate that the eggs will hatch on a weekend, you can reduce the temperature by a couple degrees to delay hatching until a weekday.

Ask students what factors might influence when the eggs will hatch. They will probably think of temperature. Students may be aware that birds sit on their eggs to make them hatch. Body heat is a form of energy and energy is needed for growth. Discuss how fish also get energy from their immediate surroundings - the water. Challenge students to think of how they could predict when their fish eggs will hatch.

Students will probably offer comments like "When they get enough heat they will hatch". Discuss the temperature of your aquarium. You have probably been monitoring this daily during the week prior to getting the eggs. Show students the chart of required thermal units and work as a class or in small groups to determine what information is needed to predict exactly when hatching will occur.

Students should write down the information and the steps they will take to get their predictions. Help them do this by writing all the relevant information on the black board - that is, the date fish were spawned, the average water temperature at the hatchery, the average water temperature in your aquarium and the number of TU's required for hatching.

Students may devise their own way of presenting the information or they may use the worksheet provided

Each day, record the water temperature. If it changes at all during the day, take two readings and find the average temperature. Make a chart to show the number of TU's that accumulate each day.

After hatching, compare predictions to what actually happened. If the fish did not hatch on the predicted day, discuss what factors might have been involved.

Watch Us Grow

Observe, draw and describe development of eggs, alevin and fry.

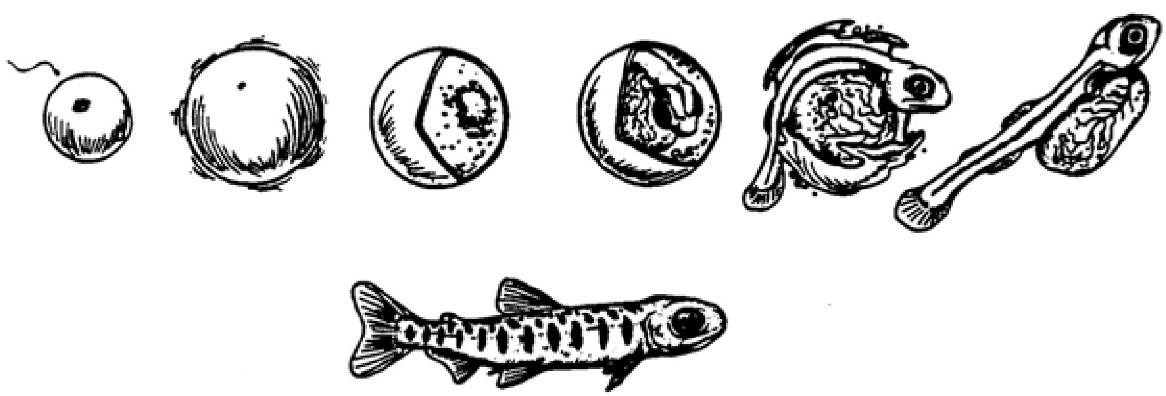
Concepts: Growth is a continual process. Salmonids undergo big changes from the time they are embryos until they are adults.

Materials

- magnifying lenses
- petri dishes or other shallow containers 1 per group of 4- 5 students
- baster
- rulers
- eggs to Fry worksheet - several for each student

The fish you raise will change dramatically during the time they spend with you. Salmon and steelhead eggs go through thirty stages of development, which can be grouped into three phases: cell division, tissue formation and organ formation. Some of the highlights of development at an average water temperature of 51^{o} are listed below.

Day 2:	Blastodisc has rounded up and is composed of 3 layers of cells
Day 10:	Eye lenses well developed
Day 11:	Cerebral hemispheres evident, segmentation of hind brain begun, pectoral fins starting to form
Day 15:	Tail becoming symmetrical, eyes becoming pigmented
Day 16:	Four gill buds evident at sides of throat, cerebral hemispheres enlarging, anal fin first noticeable, eggs are past tender period
Day 18:	Dorsal fin begins as faint thickening, nostrils first evident
Day 22:	Ventral fins now evident
Day 28:	Dorsal and anal fin rays visible, hatching begins
Day 30:	Hatching completed



Development of green egg to fry 1. Fertilization 2. Egg swells 3. Cell division starts 4. Eyed stage (cut away view) 5. Hatching 6. Alevin 7. Feeding fry

Unlike eggs, alevin are mobile, since they have fins, However, they are not good swimmers yet. The fins develop more fully during the alevin stage. Observe the yolk sac shrinking and the fish taking on a more fish-like appearance. By the time they emerge from the gravel, they will have obvious parr marks and fully functioning fins.

Swim up may be gradual, and the little fry will frequently dart back into the gravel for security. Gradually, they will spend more time in open water. They will become strong swimmers as they grow larger.

Procedure

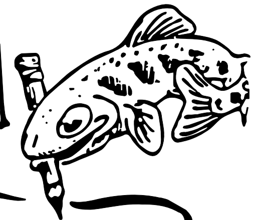
To observe fish while they are in the aquarium, students can hold a magnifying glass close to the aquarium wall. This method is the safest for the fish. You may also remove several eggs carefully with your baster. Put one egg into each petri dish, with about an inch of aquarium water. Students should work in groups of 4 or 5. Do this activity quickly, since the small amount of water will warm up, and the eggs could die. Students should not touch the eggs.

Use extreme care if you remove alevin, since they are very delicate. Again, work quickly, and gently replace the alevin to bottom of aquarium. Be sure your hands are clean and free of soap and lotion before putting them into the aquarium. Remove alevin only once. If students will observe from outside the tank, be aware that the alevin will move away from light, so be ready with those magnifying glasses.

Fry may be removed with a net. They have a higher oxygen demand, since they are bigger and more mobile. The water in the petri dish will quickly be depleted of oxygen. The fish are easiest to observe while inside the aquarium at this stage, so removal may not be necessary.

Students should draw, label and describe what they see during each observation activity. Use the worksheet provided or have students design their own.

Eggs to Fry: A Picture Journal



TODAY'S DATE ____________

AGE OF FISH (IN DAYS) ________

DRAW AND LABEL BELOW

DESCRIBE WHAT YOU SEE

____

____

____

____

____

TODAY'S DATE ____________

AGE OF FISH (IN DAYS) ________

DRAW AND LABEL BELOW

DESCRIBE WHAT YOU SEE

____

____

____

____

____

BE SURE TO INCLUDE: SIZE, COLOR, SHAPE, BODY PARTS, MOVEMENTS

FISH IN ACTION

Observe and describe how fish move breathe and respond to stimuli

Materials

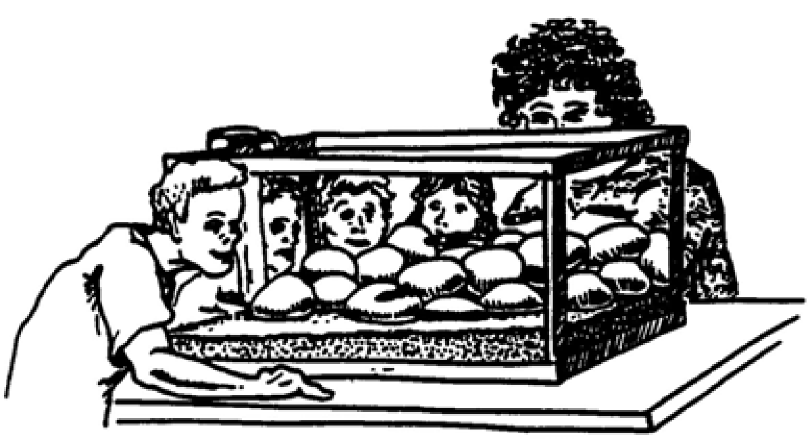
- Fish in Action Questions
- magnifying lenses
- Paper, pencils
- Chart external fish anatomy (from a curriculum, see bibliography.

Fish are well adapted to live in the water. Their shape and fins allow swift, precise movements, they have scales and slime that protect their skin from constantly being in water, they have a lateral line that senses vibrations, and they have protective coloration.

Salmon use the caudal fin (tail) to propel themselves forward, the dorsal fin on their back to stay upright and the pectorals, pelvic and anal for fine tuning the motions. Pectorals have the widest range of motion and are used to stop and turn.

Salmon eyesight is excellent. They can simultaneously see what is in the water and what is on the land much better than humans can see into the fish's world. They have ears and can hear. Their sensory perception is enhanced by the lateral line, which can sense small vibrations and probably magnetic fields. This helps all salmonids avoid predators and helps anadromous salmonids find their way during ocean migrations.

Fry have dark spots (called parr marks) and coloration that help them blend into their stream environment. It can be very difficult to see a fry against a background of gravel. When salmon and steelhead go out to sea, their back becomes very dark and their stomachs very light, which helps them escape notice from above and below.



You will most likely observe territorial behaviors and dominance hierarchies among the fry. Some fry may get bigger, because they get more food. This happens in the wild, too.

While observing the fish, avoid too much stimuli. An occasional tap on the tank or people hovering overhead will not harm the fish. Too much; however, will stress them and could promote sickness.

FISH IN ACTION QUESTIONS

Please answer these questions on a separate sheet of paper. Use whole sentences.

ALEVIN

- Describe the alevin. What color are they? Do they have fins? What is most interesting about them?
- How well do alevin swim?
- What do alevin do when light shines on them?
- How might this reaction help them survive in the wild?

FRY

Fins

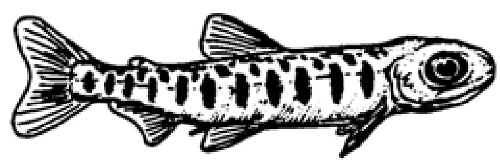
- Observe how the fish move. Try to answer these questions. .How many fins are there?
- Draw the fish and show the fins. .Label the fins.
- Describe the motion of each fin. What is the direction and range of movement? Do paired fins move together, in the same way? Are some fins used more than others?
- Fins serve different purposes. They push the fish forward, help the fish stop and turn, and help it stay upright. What is the function of each fin?
- Where are the fish's fins when it is still?

Color

- What colors do you see on the fish?
- Are the back and stomach the same color? Why are they colored like this?
- What markings do you see? What are they for?
- Look at a fish swimming near the top of the tank and one that is near the gravel. Which is easiest to see?

Senses

- Do you think fish have good eyesight? Why?
- Can the fish hear? How do you know?
- Find the lateral line. What do you think it is for?



Behavior

- What do fish do when they are startled? Why?
- Do they move as a group? What is this called?
- Are all the fish the same size?
- Describe how fish interact with each other.
- Do individuals have established areas of the tank they stay in?
- What do fish do at feeding time? Do all the fish get the same amount of food?

Farewell Finny Friends

Students prepare for releasing their fish into the wild by writing a goodbye letter or poem, signing the authorization form, and pledging to be responsible stewards of our fisheries resources.

Materials

- *Salmon and Trout Habitats*, Pages 11 & 12
- Overhead transparency of Authorization Form
- Paper and pencils

As you prepare to release your fish into the wild, students may be concerned about how they will survive. This is a good time to discuss potential problems fish might encounter in their new home, and the sources of those problems. Children should not be too pessimistic about the fate of their fish, but they should understand that there are threats.

One of those threats is the introduction of aquatic plant or animal species into environments where they are not native. Planting of hatchery fish must be done so as to cause minimum impacts to wild populations. Be sure to discuss this with the students. They should understand that this project is being done with special permission from the California Department of Fish and Game, the governmental caretakers of our natural resources.

Students will release their fry into the wild, but this is not a stocking program. The objective is not to increase fish populations in your watershed with hatchery fish, but rather to understand the fish's habitat needs and how we all can help them to survive. Because of genetic concerns and the risk of spreading diseases, Fish and Game laws and policies restrict fish planting activities. This is why you may have to release your little fry into a river that is not near your school.

Show students the authorization form and discuss the conditions it lists. Talk about why moving species of plants and animals can be devastating to an ecosystem. An example is the Eel River, where temperatures have increased over the last few decades because of land uses and droughts. In addition, someone released Sacramento Squawfish into the upper basin. They survive well in warm water, and the river now has a large population. These fish, which do not belong in the Eel River, are predators of salmon and trout. This introduced predator, along with degraded habitat, have hurt salmonid populations.

Students may sign the back of the authorization form. Whether you choose to do this or not, make sure students know there are rules governing fish planting. Encourage them to write pledges to be a good stewards of aquatic resources.

Look at the pictures of different types of salmonid habitats, and talk about where your fish will live. Will they ever migrate out to sea? What will they need in their new home? What would the ideal home look like? Students may draw pictures of this place, and write a poem or letter to the fish to express their feelings. They may want to give the fish advice on how to survive.

Pre-trip Preparation

You should visit the release site before your fieldtrip. Check for bus access, safe footing and trails that will minimize impact to stream area and reduce risk of accidents. Take the temperature of the stream. Look for a release site in a side channel or backwater areas, where the flow is gentle. Look around for some kind of cover, such as roots, logs, and rocks. Check out possibilities for other activities, such as aquatic insect identification, riparian survey, flow measurements, etc. See if a volunteer from a local fly fishing club can come with you to help.

The Release

When you first arrive at the release site, place the bucket in the stream. If there is a large difference between stream and bucket water temperatures, you can wait for bucket to equalize, or you can slowly and gradually add stream water to the bucket. Do not shock the fish with quick changes in temperature. The temperature of the water in the bucket needs to be within 5° of the stream water.

While you're waiting, have students check for all the conditions fish need. Take the temperature of the water. Note how much shade is provided by riparian vegetation or canyon walls. Use a net or pick up rocks to find aquatic insects. Look around for the places where fish will hide. You could even take a pH and dissolved oxygen reading.

To let the fish go, each student may scoop out one or two and let them go individually. Or, have several students slowly tip over the bucket after temperatures have equalized.

Glossary

alevin	A newly hatched salmon or trout with a yolk sac attached to its stomach. The alevin lives in the rocks in the streambed.
anadromous fish	Those fish that spend the greater share of their lives in salt water but migrate into fresh water stream for reproduction.
aquarium	A tank or other suitable container in which fish and other aquatic organisms may be maintained.
aquatic	Growing, living in, or frequenting water.
bubble curtain	Where you cannot see through the water because there are lots of bubbles.
cascade	Falling water
catadromous fish	A species of fish that begins its life in the ocean, Then lives most of its life in fresh water, and returns to the ocean to spawn.
catch limit	The number of fish that a person can legally catch in one day.
chinook	One of five species of salmon.
cobbles	Stream rocks that are 2-10 inches across. (From the size of a person's fist to the size of a person's head)
coloration	A genetically controlled pattern or marking that protects an individual organism.
confluence	The place where two streams come together.
dissolved oxygen	Molecules of oxygen gas dissolved in water.
ecology	The study of the relation of organisms or groups of organisms to their environment; the science of the interrelations between living organisms and their environment.
egg	An ovum which when fertilized may develop into an animal.
erosion	The process by which water, wind, and temperature break down rock and soil into small loose particles. They may be swept away by wind or water or both.
estuary	The area where the river meets the ocean and the fresh water

	mixes with the salt water.
eyed eggs	Salmon and trout eggs that have developed eyes. The eyes show as big dark spots in the egg.
fish ladder	A series of ascending pools of water constructed by humans as mechanisms to enable salmon or other fish to swim upstream around or over a dam.
food chain	The transfer of food energy from the source in plants through a series of animals, with repeated eating and being eaten.
fry	A small young fish that have recently hatched.
gill covers	The skin that covers fish's gills
gills	Organs on both sides of fish’s head that take oxygen from the water so fish can breathe.
gravel	Rocks that are between 1/10 inch and 2 inches across.
hatchery	A place where fish are spawned and eggs are hatched. The fry are raised and then put into streams.
habitat	The arrangement of food, water, shelter, or cover and space suitable to animals needs.
homing	When salmon return to their home stream after spending years in the ocean.
imprinting	When the smells of a river and watershed are "stamped" into a salmon's brain. The salmon make a scent memory.
incubate	To keep the eggs or fry at the optimum and supplied with moisture and oxygen so they will hatch and grow.
lateral lines	A special line of cells on each side of a salmon or trout’s body. The lines are used to sense motion and magnetic fields.
license	In wildlife terms, a legal permit, to hunt, fish, trap, transport, keep captive wildlife or perform taxidermy.
life cycle	The continuous sequence of changes undergone by an organism from one primary form to the development of the same form again.
migration	To move from one place to another, usually in a group. Salmon migrate out to sea and then back to the river where they were born.

mucous	A slippery liquid usually in places of a body where the inside meets the outside, like in the mouth.
ocean	Very large bodies of salty water that make up most of the earth.
parr marks	Marks on the sides of a salmon and trout fry that are almost round. Helps the fish hide from predators by making it look like its surroundings.
plunge pools	Pools that are made when water falls over a rock or log and scours out a hole.
pollution	Contamination of soil, water, or atmosphere by the discharge of harmful substances.
pool	A place in the stream where the water flows very slowly and the surface is smooth. Pools are usually deeper than other areas.
predator	An animal that eats other animals.
redd	A salmon nest. Made in rocks in the stream bed. A place where someone goes to be safe from harm.
riffle	A place in a stream where the water flows quickly over rocks. The surface of the water is choppy.
run	A group of salmon that come back to a river together to spawn.
scales	Small, plate-like things that cover a fish's body. The scales are made of material like fingernails.
school	A group of fish that swim together for protection.
scour	To dig out a hole.
sediment	Very small pieces of rock that wash into streams. Too much sediment is not good for fish.
silt	Very fine particles of rock, like sand.
smolt	A salmon that has lost its parr marks and is ready to go out to sea.
spawn	Making new life. A female fish lays eggs and a male fish fertilizes them.
yolk sac	A "bag" of food that is connected to the stomach of a very young salmon.

REFRIGERATOR CONVERSION

Designed by Rich McGowan of Redwood Empire Trout Unlimited and the San Joaquin Valley and Southern Sierra Region of the California Department of Fish and Game. A more detailed manual is available from the SJVSS Region of the Department of Fish and Game.

Introduction

There are various methods used to incubate salmonid eggs in a classroom setting. The method given here has proven effective in many classrooms. Cost for this project is relatively low; durability and dependability of the unit relatively high. The construction of the incubator unit can be accomplished by anyone with average mechanical skills. However, if questions arise, consult appropriate professional personnel. Order parts necessary in advance. Average assemble time per unit is approximately 2 hours.

Read and follow all manufactures' instructions before starting modifications.

The following items contain separate instructions;

- Ground Fault Intercept Duplex Outlet (GFI)
- Temperature Control Thermostat (Dayton mode12E399)
- Dimmer Switch

<u>Wiring should follow all appropriate electrical codes. Use caution when drilling or cutting in door or side of refrigerator. Many of the newer refrigerator have their cooling coils buried in the sides and not on the back.</u> Plastic interior and metal exterior crack easily. Drill and cut holes slowly. Always wear proper eye protection and be aware of sharp edges.

MATERIALS LIST PER UNIT

1 3.6 cubic foot refrigerator
1 Temperature control thermostat (Dayton Model 2E399)
1 Pre-made viewing window frame (approximately 10 X 10 inches)
1 1/4 inch temperature glass or 1/8 inch plexiglass to fit window frame
1 I5-amp Ground Fault Intercept (GFI) duplex outlet
1 Dimmer switch
1 Double bell box with four 1/2 inch knock out (KO)
1 Cover plate for GFI and dimmer switch
1 1/2 inch offset nipple and lock nuts
2 1/2 inch cord clamps
1 6 to 8 foot 16-gage/3 strand (1 6-3) grounded small appliance cord
1 1 foot each of the following colors of 16 gage wire: black, white, green
1 Rubber-coated light socket with black and white leads
10 1/2 inch self tapping sheet metal screws (#8 or #10)
1 8 X 16 X 1/2 inch plywood for aquarium shelf
Silicone, wire nuts, 1/2 inch pipe insulation

TOOLS REQUIRED

Drill and assorted drill bits
Hole saw 1 1/2 inch diameter
Saber saw and blades
Screw Drivers, Standard and Phillips
Wire cutter and stripper
Fine tooth half-round file
Wood rasp
Electrical test meter
Caulking gun
Sandpaper #80 to # 1 20 grit

REFRIGERATOR MODIFICATON

Always wear proper eye protection and be aware of sharp edges

STEP 1. Viewing Window.

Remove door from refrigerator. Remove any shelf brackets or rails from the inside door. **Figure 1a**.

Make a cardboard templet the same size as the hole required to fit the viewing window frame. Place the templet on the door approximately 9 inches from the door bottom.
Center the template from side to side and trace a line around it.

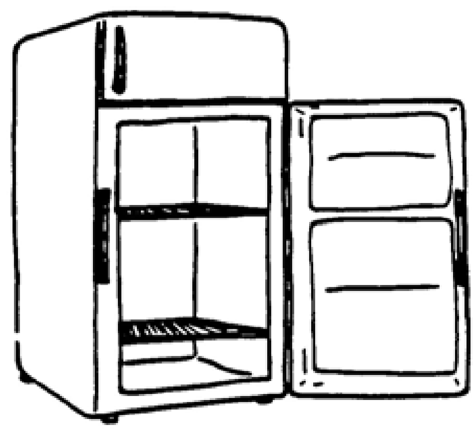


Fig. 1a

Drill 4 pilot holes, one in each coner of the viewing window templet line. These pilot holes must be large enough to fit the saber saw blade. Cut hole for viewing window with saber saw. Remove sharp edges with file. Use caution when drilling or cutting in door or side of refrigerator.
Plastic interior and metal exterior crack easily. Drill and cut holes slowly. **Figure 1b.**

Install pre-made viewing window frame and window into door and silicon neatly gaps. Note: Some plastic shim material may be needed on interior side of door to make window fit snugly.

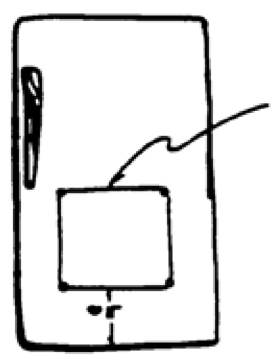


Fig. 1b

Step 2 Access Holes.

Drill hole for light fixture. Drill hole for access of airlines, pump cord, temperature control thermostat and condensation vent line. These two holes can be placed on the side of the refrigerator just below the freezer drippan. Each hole is 1 1/2 inches in diameter. One hole is placed approximately 5 inches from front of refrigerator; the other is placed approximately 3 inches from rear of refrigerator. Use caution when drilling or cutting in door or side of refrigerator. Plastic interior and metal exterior crack easily. Drill and cut holes slowly. Figure 2.

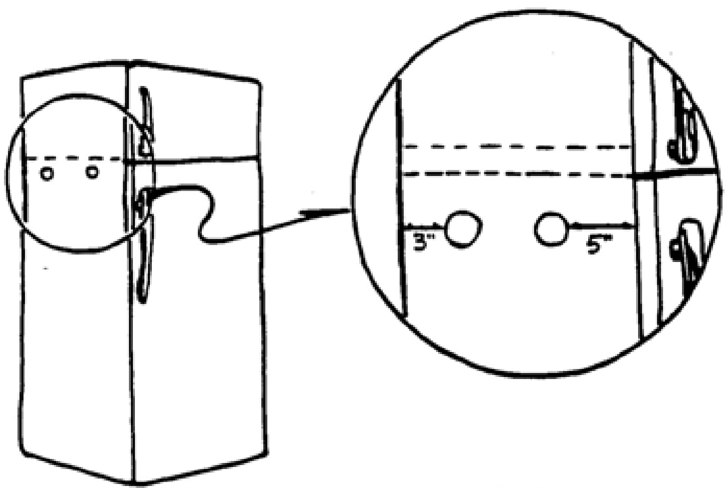


Fig. 2

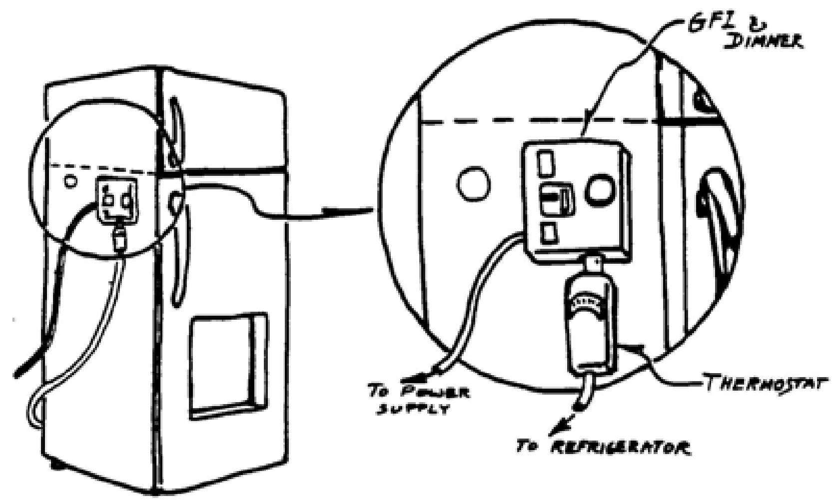


Fig. 3

Step 3 Mount Controls.

Place center of knock-out in back of double bell box over center of access hole for light fixture. Mount to side of refrigerator with self-tapping sheet metal screws.

Attach 1/2 inch offset nipple to top of temperature control thermostat. Attach remaining end of 1/2 inch offset nipple to a knockout in bottom of double bell box.

Adjust temperature control thermostat flush with refrigerator side and mount with self tapping sheet metal screws. Figure 3.

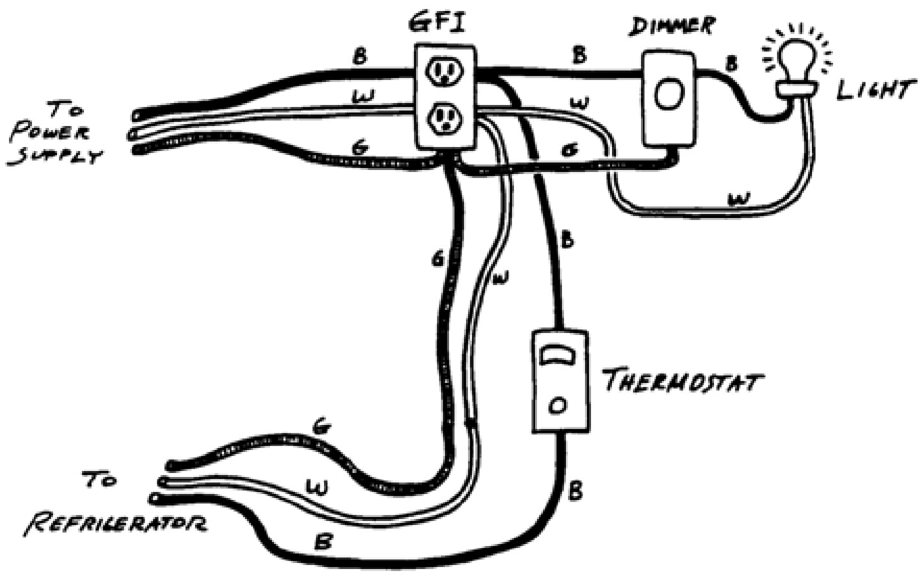
Step 4 Electrical Wiring

Connect one black wire from the dimmer switch to the bronze load terminal of the GFI duplex outlet. Connect black wire from light socket to other black wire of dimmer switch. Connect white wire from light socket to silver load terminal of GFI duplex outlet.

Cut plug off refrigerator cord and connect black wire to white labeled terminal on temperature control thermostat. Connect white wire from refrigerator cord to silver load terminal of GFI. Connect -green wire from refrigerator cord to ground terminal of GFI duplex outlet. Connect a piece of black wire from the red labeled terminal of temperature control thermostat to bronze load terminal on GFI duplex outlet.

Connect 3 wire small appliance power cord to line side of GFI plug; black wire of cord to bronze line terminal, white wire to silver line terminal and -green wire to ground terminal of GFI outlet.

Fig. IV



Mount GFI duplex outlet and dimmer switch into double bell box.

Wiring should follow all appropriate electrical codes. Read and follow all manufactures' installation instruction before starting modifications.

Build aquarium support shelf and install. Run all air intake lines, condensation escape lines and pump power cords through the access holes. Fill remainder of hole with foam pipe insulation.

Prepare aquarium and install. Hook up power head and place thermostat into a separate jar of water placed next to aquarium. **Do not put copper sensor in aquarium water.**

Potential Sources for Chiller Equipment

Glacier Corporation
2800 S. Main #K
Santa Ana, CA 92707

(714) 557-2826

Website at: www.glaciercorp.com

Taylor Refrigeration Ltd.
6662 Apollo Rd.
Vernon, B.C. Canada V1H1J3

(250) 545-4906   FAX (250) 545-5975

Email rcoutts@junction.net

Universal Marine Industries, Inc.
1815 Williams Street,
San Leandro, CA 94577

(510) 352-9856

www.umi.net

Ward's Biology
(800) 962-2660

BIBLIOGRAPHY

Note: This bibliography was not revised in 1999. The availability and prices of these resources may have changed.

Adopting A Stream: A Northwest Handbook*.* Steve Yates. University of Washington Press, P.O. Box 50096, Seattle, Washington 98145-5096. A nicely illustrated book that describes physical and biological aspects of streams and watersheds, Examples of Adopt-A-Strearn projects are given. Available through bookstores or directly from publisher.

Aquatic Resources Education Curriculum*.* Available from Order Department. Kendall Hunt Publishing Company, P.O. Box 539, Dubuque, Iowa 52001 (800) 338-5578 $20.00 Information for teaching fishing techniques, water safety and aquatic life,

California's Salmon and Steelhead: Our Valuable Natural Resource, Diane Higgins, 4649 Aster Road. McKinleyville, CA 95519. Lesson plans and reference materials for teaching about anadromous salmonids, Chapters include fish as organisms, life cycles, habitat needs, importance to people, threats to fish, restoration and conservation, glossary and bibliography.

Clean Water, Streams and Fish: A Holistic View of Watersheds. Wendy Borton, et.a1. Washington State Office of Environmental Education. 17011 Meridian Ave., Seattle, Washington 98137, (206) 542-7671, Available at elementary and secondary levels, Covers salmon life cycle and habitats, watershed management and economic issues.

Discovering Salmon: A Learning and Activity Book. Nancy Field and Sally Machlis. Dog Eared Publications, P.O. Box 620863, Middleton, WI 53562-0863. A wonderful collection of coloring and reading activities about salmon species, life cycles, anatomy, habitats, endangered and threatened species.

Earth: The Water Planet. Jack Gartrell, et. al. Special Publications, National Science Teachers Association. 1742 Connecticut Ave. N.W. Washington, D.C. 20009. Contains lessons for the middle grades on groundwater, erosion, river dynamics, global water distribution and physical properties of water.

Field Manual for Water Quality Monitoring An Environmental Education Program for Schools*,* Mark K. Mitchell and William B. Stapp. Order from William B. Stapp 2050 Delaware Ave. Ann Arbor Michigan 48103. Very useful for helping you and your high school students establish a water monitoring program. Includes methods for measuring and evaluating physical and biological parameters of stream conditions.

Klamath River Studies*.* Diane Higgins. Klamath River Educational Program.   4649 Aster Road, McKinleyville, CA 95521.6 curriculum guides including:

Grades K-3: Combines science with literature. Lessons are based on a 16 chapter illustrated story about a spring salmon, *Springer's Quest*

Grades 4-6 & 7-8 guides focus on anadromous fish, river restoration, river monitoring projects-lesson plans, games, student readings, aquatic insect keys, many illustrations.

High School *Fisheries and Watersheds Unit* is comprised of stream site monitoring activities and 6 research projects focusing on fish populations and characteristics of watershed.

Chemistry Unit has lessons about pH. D.O., temperature, biogeochemical cycles and how affected by land uses.

Social Studies is *CA Water Distribution, Use* & *Conservation.*

Living In Water An Aquatic Science Curriculum*.* Valarie Chase. National Aquarium in Baltimore, Dept. of Education and Interpretation. Pier 3, 501 East Pratt Street, Baltimore, Maryland 21202. Write directly to Dr. Chase to order. Lessons for grades 4-6. Includes sections on substances that dissolve in water, temperature changes in aquatic habitats, moving or staying put: maintaining position within aquatic habitats, light and water, exploration. research and communication.

Project Wild Aquatic*,* Western Education Foundation. Available at no cost at workshops. Contact CDFG Project Wild Aquatic Coordinator at. 916-653-6132 regarding workshop dates & locations. This guide has many excellent activities about aquatic ecosystems, management and environmental ethics.

The Stream Scene: Watersheds, Wildlife and People. Patty Farthing, et. al., Oregon Department of Fish and Wildlife, Office of Public Affairs, PO Box 59, Portland. Oregon. 97207 (503) 229-5400. $15.00. A 6-12th grade curriculum with sections on Water Cycle, Watersheds, Riparian Areas, Hydrology, Water Quality, and Aquatic Organisms.

Sport Fishing and Aquatic Resources Handbook. Bob Schmidt Kendall Hunt Publishing Co. An Aquatic Resources Education Curriculum. Illustrated reading and activities about bodies of water, fishing techniques, safety and ethics.

<u>Slide Shows:</u>

California's Salmon and Trout*.* 80 slides with written script covering life cycles of both anadromous and resident trout, their habitats, causes for declines, and restoration and conservation opportunities. Diane Higgins 4649 Aster Rd., McKinleyville, CA 95521

Habitats of Salmon And Steelhead 65 slides with written script covering life cycles of both anadromous salmonids and the habitat that supports them at each stage of the life cycle. Diane Higgins 4649 Aster Rd., McKinleyville, CA 95521 (707) 839-4987

These slide shows are also available on loan. Make your request at least 4 weeks in advance.

<u>Videos</u>

To Quench a Thirst Water Education Foundation 1991. 717 K Street, Suite 517 Sacramento, CA 95814 (916) 444-6240. Deals with conflicts and solutions to water use and allocation in California. $25.00 plus shipping, (www.watereducation.org)

Schedadwx U.S.D.A., Forest Service. 30 minutes. Good overview of problems that have caused declines in salmon and steelhead and restoration efforts. Contact the Supervisor's Office for the National Forest near you, or your regional U.S.F.S. office.

Where the Trout Are Federation of Fly Fishers (See below)

The Way of the Trout Trout Unlimited and Scientific Anglers, 1985. 30 minutes. For information about these two films, contact Trout Unlimited, 1500 Wilson Blvd. Suite 310 Arlington, VA 22209-2310 (703)522-0200. Or, contact your local chapter of Trout Unlimited or Fly Fishers about borrowing a copy.

Other Books and Materials

California's Rivers: A Public Trust Report*.* California State Lands Commission. 1993. Send requests to California State Lands Commission 1807 13th St. Sacramento, CA 95814. Phone: (916) 322-6577 Fax: (916) 322-3568.

An excellent resource for you and your student, this report is broad and deep, and very readable. It contains information on any aspect of rivers you find of interest.

California's Wild Heritage Threatened and Endangered Animals in the Golden State*.* Peter Steinhart. 1990. Order from California Department of Fish and Game, Continuing Education 1416 9th Street, Sacramento, CA 95814.

Life on the Edge A Guide to California's Endangered Natural Resources*.* BioSystems Analysis, Inc. 1994. Distributed by Heyday Books, P.O. Box 9145 Berkeley, CA 94709 (510) 549-3564 and BioSystems Books 303 Potrero Street, Santa Cruz, CA 95060-2719 (408) 459-9100 (800) 9830-5433.